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WHY IS SEA-WATER SALT?

BY W. MATTIEU WILLIAMS, F.R.A.S., F.C.S., LONDON, ENGLAND.

THIS question has been regarded as a mystery and has given rise to some curious speculations, but a little consideration of the subject must, I think, satisfy us all that it would be very wonderful, quite incomprehensible, if the waters of the ocean were otherwise than salt as they are.

The following explanation was first suggested to myself many years ago when receiving my first lessons in practical chemical analysis. The problem then to be solved was the separation of the bases dissolved in water by precipitating them, one by one, in a solid condition; filtering away the water from the first, then from this filtrate precipitating the second, and so on, until all were separated or accounted for.

But in doing this there was one base that was always left to the last, on account of the difficulty of combining it with any acid that would form a solid compound, a difficulty so great that its presence was determined by a different method. This base is soda, the predominating base of sea-salt, where it is combined with hydrochloric acid. Not only is soda the most soluble of all the mineral bases, but the mineral acid with which it is combined forms a remarkably soluble series of salts, the chlorides. Thus the primary fact concerning the salinity of sea-water is that it has selected from among the stable chemical elements the two which form the most soluble compounds. Among the earthy bases is one which is exceptionally soluble,—that is, magnesia,—and this stands next to soda in its abundance in sea-water.

Modern research has shown that the ocean contains in solution nearly every element that exists upon the earth, and that these elements exist in the water in proportions nearly corresponding to the mean solubility of their various compounds. Thus gold and silver and most of the other heavy metals are found to exist there. Sonnenstadt found about 14 grains of gold to the ton of sea-water, or a dollar's worth in less than two tons.

As the ocean covers all the lower valleys of the earth, it receives all the drainage from the whole of the exposed land. This drainage is the rain-water that has fallen upon this exposed surface, has flowed down its superficial slopes, or has sunk into porous land, and descended under-ground. In either case the water must dissolve and carry with it any soluble matter that it meets, the quantity of solid matter which is thus appropriated being proportionate to its solubility and the extent of its exposure to the solvent. Rain when it falls upon the earth is distilled water nearly pure (its small impurities being what it obtains from the air), but river-water when it reaches the ocean contains measurable quantities of dissolved mineral and vegetable matter. These small contributions are ever pouring in and ever accumulating. This continual addition of dissolved mineral salts without any corresponding abstraction by evaporation has been going on ever since the surface of the earth has consisted of land and water.

An examination of the composition of other bodies of water, which, like the ocean, receive rivers or rivulets and have no other outlet than that afforded by evaporation, confirms this view. All of these are more or less saline, many of them more so than the ocean itself. On the great Table Land of Asia, "the roof of the world," there is a multitude of small lakes which receive the waters of the rivers and rivulets of that region and have no outlet to the ocean. On a map they appear like bags with a string attached, the bag being the lake and the string the river. All these lakes are saline, many of them excessively so, simply because they are ever receiving river-water of slight salinity and ever giving off vapor which has no salinity at all. There is no wash through these lakes as in the great American lakes or those of Constance, Geneva, etc.

The Sea of Aral and the Caspian are lakes without any other outlet than evaporation, and they are saline accordingly. The Dead Sea, which receives the Jordan at one end and a multitude of minor rivers and rivulets at its other end and sides, is a noted example of extreme salinity. It is, as everybody knows, a sea or lake of brine. The total area of land draining into the great ocean does not exceed one-fourth of its own area, while the Dead Sea receives the drainage and soluble matter of an area above twenty times greater than its own, and thus it fulfils the demand of the above-stated theory by having far greater salinity than has the great ocean.

According to this view the salinity of the ocean must be steadily though very slowly increasing, and there must be slowly proceeding a corresponding adaptation or evolution among its inhabitants, both animal and vegetable. The study of this subject and the effect which the increasing salinity of the past must have had upon the progressive modifications of organic life displayed by fossils is, I think, worthy of more attention than it has hitherto received from palæontologists.

THE ENERGY-FUNCTION OF THE MAGNETIC CIRCUIT.

BY CHAS. P. STEINMETZ.

IN designing alternate-current electric motors, in October, 1890, I was confronted by the problem, to calculate the loss of energy caused by the reversals of magnetism in the iron of the motor-field. At that time very little was known on this phenomenon besides a few experimental data of Ewing. From these data mathematical analysis yielded the result that the loss of energy (by conversion into heat) during a complete cycle of magnetization is proportional to the 1.6 power of the intensity of magnetization, or magnetic induction, B; that is, can be expressed by the formula: —

$$H = \eta B,^{1.6}$$

where H is the loss of energy per magnetic cycle, and η a "co-efficient of hysteresis." This result was published in the *Electrical Engineer*, New York, December, 1890.

But it was not quite satisfactory, in so far as Ewing's determinations were made by the magnetometer method, with very slow cyclic variations of magnetism, and it was doubtful whether for very quick cycles, as they take place under the influence of an alternate-current of 100 or more complete periods per second, the same law holds, and especially the co-efficient of hysteresis, η, is the same.

A great number of tests, made during the year 1891, partly by the three electrodynamometer method, partly by the use of the Eickemeyer differential magnetometer, and published in a paper read before the American Institute of Electrical Engineers, January, 1892, proved that up to over 200 complete magnetic cycles per second the loss of energy per cycle — by conversion into heat — is constant and independent of the number of cycles per second, following the law of the 1.6 power; while, when under the influence of the alternating magnetism, Foucault — or eddy — cur-